ASSESSEMENT OF UNCERTAININTY ANALYSIS OF MINE FANS BY STUDYING VENTILATION NETWORK DESIGN

A THESIS SUBMITTED IN PARTIAL FULLFILLMENT OF THE

REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology

In

Mining Engineering

By

ROSHAN LAKRA

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DEPARTMENT OF MINING ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

ROURKELA – 769008

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National Institute of Technology
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CERTIFICATE

This is to certify that the thesis entitled **"Assessement of uncertainity analysis of mine fans by studing ventilation network design"** submitted by Sri Roshan Lakra (Roll No. 109mn0474) in partial fulfilment of the requirements for the award of Bachelor of Technology degree in Mining Engineering at the National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any Degree or Diploma.

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ABSTRACT

The objective of a ventilation network system is to provide the desire quantity of airflows throughout the mine such that the workers can work underground in a safe and healthy environment at the level specified by the mining regulations.

In coal mines the ventilation network system has a greater impact on safety and production. The selections of mine fan and air quantity calculation at different working places are generally decided by solving the ventilation network using iterative Hardy-Cross method

In this thesis, an approach was adopted to simulating the ventilation network considering the airways resistances as uncertain variables. A Monte-Carlo simulation-based approach was followed to generate random set of resistance values from the distribution functions of the airways resistances. The VENTSIM software was used to solve the Hardy-Cross method for ventilation network simulation using one set of random resistance values. The Monte-Carlo simulation based approach helps to analysis the uncertainty of air quantity at specific working faces as well as total quantity required for ventilating the mine. The major focus of the thesis is towards the quantity of air in the working face generated by the mine main fan and the risk involve with the selection of mine main fan for a coal mine.

The methodology for the ventilation network design proposed in this thesis was applied in a underground coalmine in Eastern part of India. The airways resistances are calculated by measuring the values at different places in same airways. The mean and standard deviation used for Monte-Carlo simulation assuming the distribution is Gaussian. A total number of 71 airways are simulated in the case study mine. A risk analysis of quantity of air reaching at face was performed at two working faces by generating 200 realizations The results in this thesis was validated my measuring quantity at different measuring station in this mine.

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Chapter 1

INTRODUCTION

INTRODUCTION

Underground mine ventilation is an utter important job for the occupational health and safety of underground employees (Ramani 1992a). Underground mine ventilation provides a flow of air to the underground workings of a mine of sufficient volume to dilute and remove noxious gases, typically NOx, SO_2, methane, CO_2 and CO. The underground atmosphere is contaminated from dust, aerosols, diesel fumes and particulates and fumes from strata by various operations. Oxygen reduction may also take place due to recirculation of ventilating air where diesel engines are operating. To protect employees against the risk and the consequences of underground fires and unplanned explosions, it is important to maintain a healthy working environment underground (Bandopadhyay 1992). Correct design, implementation and maintenance of mine ventilation is therefore of fundamental importance.

The largest component of the operating cost for mine ventilation is electricity to power the ventilation fans, which may account for one third of a typical underground mine's entire electrical power cost. The design of ventilation system in an underground mine has several considerations to be made to solve the problems arising from it like wear of machine parts, decrease in efficiency of the fan with time, estimating the quantity of air required in the mine to ventilate each district properly, the maintenance of pressure, selection of proper installation site of the fan, resistance offered by the roadways, supports, stoppings, etc.

Design methods of mine ventilation system can be categorized into three groups: (1) analytical methods, (2) empirical methods and (3) observational methods (Ramani 1992b). Analytical methods deal with fundamental concepts of fluid mechanics in conjunction with applied mathematics. Empirical methods include the governmental, health and safety regulations as well as experimental rules. Observational methods rely on consistently monitoring the ventilation system in the course of time. Incessantly measuring and inspecting the amount of harmful or explosive gases, air velocity and quantity and air pressure are the chief essence of this method. Therefore, a primary ventilation system cannot be developed unless observational methods are taken into account. Using the above mentioned methods appropriately, a perfect ventilation system for both initial and further stages of mining will be achieved.

The control of primary ventilation flows or circuits in a mine requires careful planning from the design stage and thereafter throughout the operating life of the mine. For initial design of any mine or a planned upgrade, the computer simulation of the ventilation network is helpful for solving complex ventilation systems with many features including fan selection and optimal fan location selection; determining optimal fan settings for efficient operation; determining the amount of regulation required to control airflow; selection of locations for doors and regulators; determining the effect of air leakage on the overall system; and, determining possible effects of improvements/changes to airways (Hartman, 1997):

To simulate airflows, quantity, resistance, pressure and heats and many other types of ventilation data from a modeled network of airways, different ventilation software are used. To develop a computerized monitoring system to provide immediate or real time simulated information on each branch within an underground ventilation network. The system measures airflow or air pressure changes in selected ventilation branches and simulates flows through all mine sections. Once the simulation program has updated readings it can remodel the whole mine system, report the flows in all branches and compare individual branch readings with expected values.

The conventional approach to ventilation network simulation considered the deterministic airways resistance. However, major shortcoming of this approach is that the uncertainties related to lack of accurate airways resistance parameters, errors in measuring airway length and perimeters properties leads to wrong simulated results.

Due to the importance of ventilation network simulation, determination of airways air quantity has a significant consequence to decision makers. With respect to the uncertainties of airways resistance parameters, utilizing risk analysis is essential for ventilation performance. Conventional approaches do not take into account many uncertainties in their calculations quantitatively. To avoid such misleading results, probabilistic approaches of the ventilation network simulation with reliability analysis is preferred.

Objectives:

In order to solve the problems incurring in mine ventilation design with uncertain airways resistance, it is highly essential to simulate the mine ventilation network. Hence the objective of this study includes:

- Network Simulation by Hardy Cross method.
- Incorporating the uncertainty for the airways.
- Risk analysis by Monte Carlo simulation
- Validation of the model.

Chapter 2

LITERATURE REVIEW

LITERATURE REVIEW:

2.1. Tradition approach of ventilation:-

The major purpose of the methods was to ventilate the working areas. In the tradition method the volume of air flow in the working areas determined at a preliminary stage of planning and the empirical values of the airflow based on tonnage can also be used. The airflow required by different parts of the mine like the development areas, mechanical plant, leakage are estimated. In many mines the efficiency is very low. Inaccuracies in estimates of airflow through each leakage paths cause major error in main ventilation path. The square law, $p=RQ^2$, cause twice the percentage error in the frictional pressure drop. To solve the leakage along the path was the major challenge faced by the traditional method of ventilation. The quantity of airflow Q is estimated in every major airways. By using the the given size of airways and airflow determine the air velocity. The need for the additional airways can be made. The resistance, R of is determined either from estimated frictional factors or on the basis of local empirical data. Using the square law, $p = RQ^2$ detrmine the frictional pressure drop for individual airways.

2.2. Mine Fan

A fan is a device that utilizes the mechanical energy of a rotating impeller to produce both movement of the air and an increase in its total pressure. Primary mine fans are generally either centrifugal fans or axial flow fans. Most fans today are of the axial flow type (Hartman et al. 1997).

Mine fans were classified in terms of their location, main fans handling all of the air passing through the system, booster fans assisting the through-flow of air in discrete areas of the mine and auxiliary fans to overcome the resistance of ducts in blind headings.

Fans may also be classified into two major types with reference to their mechanical design. A centrifugal fan resembles a paddle wheel. Air enters near the center of the wheel, turns through a right angle and moves radially outward by centrifugal action between the blades of the rotating impeller. Those blades may be straight or curved either backwards or forwards with respect to the direction of rotation. Each of these designs produces a distinctive performance characteristic.

An axial fan relies on the same principle as an aircraft propeller, although usually with many more blades for mine applications. Air passes through the fan along flow paths that are essentially aligned with the axis of rotation of the impeller and without changing their macro-direction.

Fan total pressure can be divided into two components i.e. Fan static pressure and fan velocity pressure

Fan velocity pressure is the average velocity pressure at fan outlet only. Fan total pressure is the increase in total pressure due to fan. Fan static pressure is the difference between the fan total pressure and fan velocity pressure.

In deep mines or where workings have become distant from surface connections the pressures required to be developed by main fans may be very high in order to maintain acceptable face airflows. This leads to practical difficulties at airlocks and during the transportation of personnel, mined mineral and materials. More serious, however, is the fact that higher pressures at main fans inevitably cause greater leakage throughout the entire system. Any required fractional increase in face airflows will necessitate the same fractional increase in main fan volume flows for any given system resistance. Hence, as both fan operating power and costs are proportional to the product of fan pressure and airflow, those costs can rapidly become excessive as a large mine continues to expand. In such circumstances, the employment of booster fans provides an attractive alternative to the capital penalties of driving new airways, enlarging existing ones, or providing additional surface connections.

Unlike the main fans which, in combination, handle all of the mine air, a booster fan installation deals with the airflow for a localized area of the mine only. It has frequently been the case that the installation of underground booster fans has resulted in improved ventilation of a mine while, at the same time, producing significant reductions in total fan operating costs. Furthermore, if booster fans are improperly located or sized then they may result in undesired recirculation.

2.3. Mine fan selection:

A fan is a mechanical device which utilizes the mechanical energy of a rotating impeller to produce the required quantity of air and increase in its total pressure. So the selection of proper fan for the mine is important. The selection of the mine fan can be done in the planning stage , for more detailed selection the nomogram method can also be used, an exact selection with the help of a complete technical data can be done by using computer based programs.

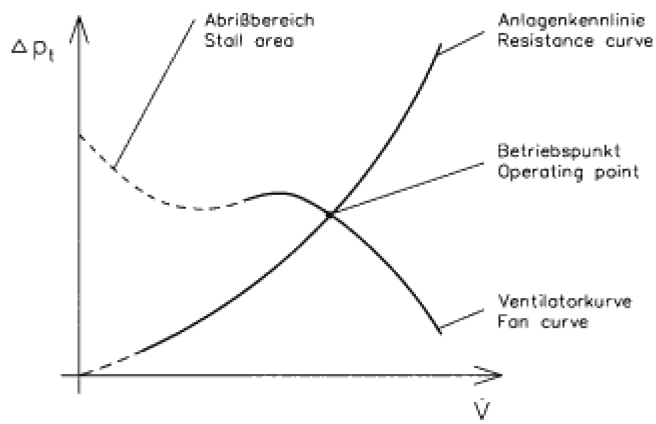

Figure1. operating point of the fan

The selection of fans is based on fan curve data provided by the manufacturer's. A fan is selected on the basis of the available pitch setting. Although at this point in time, the cost of a fixed pitch fan is the same as an adjustable pitch fan (Spendrup 2005).

2.4. Booster fan

A booster fan basically used in underground mines installed in series with a main surface fan which is used to boost the pressure of air current passing through. It can also be used to reduce air leakage and decreased main fan pressure.

Advantages:

- Increase flow rates.
- Equally distribute the air through out the mines.
- Provide air to area difficult to access.
- Increase flow of the air in heavy resistance airways paths.

Disadvantages:

- Problems if main fan /booster fan stops.
- Heavy noise, dust generated by booster fans.
- It reduce ability to control recirculation of mine air.
- Ventilation can be interrupted upto a greater extent if booster fan stop working.

Chapter 3
METHODOLOGY

3. METHODOLOGY

3.1 Ventilation Circuits

A ventilation network is similar to an electrical circuit diagram in which the wires are the branches(underground openings), nodes are the intersections and the consumers are the people, equipment. Once the consumers are established for a given production, the calculations that follow are based on Kirchhoff's Laws.

Kirchhoff's first law states that "the mass flow entering a junction equals to the mass flow leaving that Junction", mathematically the form of this law is,

$$\Sigma_i M=0$$

where *M* are the mass flows, positive and negative, entering junction i.

$$\sum_{i=1}^{n} Q_i \cdot \rho_i = 0$$

where:

Qi – airflow in branch i, m3/s

ρi – air density in branch i, Kg/m3

i – number of branches in the network

Kirchhoff's second law states that "the algebraic sum of all pressure drops around a closed path, or mesh, in the network must be zero, having taken into account the effects of fans and ventilating pressures".

$$\Delta u^2/2 + \Delta z \cdot g + w = \int V \cdot dP + F$$

where:

u – air velocity, m/s

z – elevation above the reference, m

w – work input from fan, J/Kg

V – specific volume, m^3/Kg

P – barometric pressure, Pa

F – work done against friction, J/Kg

The terms Δz and Δu2/2 will be approaching zero as the mesh is closed. The term - ∫ V • dP is the natural ventilating energy. With these two changes, the new form for this law becomes:

$$\boxed{\sum_{i=1}^{n}(F_i - W_i) - NVE_i = 0}$$

And, if we convert this in pressure units:

$$\boxed{\sum_{i=1}^{n}(\rho \cdot F_i - \rho \cdot W_i) - \rho \cdot NVE_i = 0}$$

where ρ is the standard air density, Kg/m3.

So the final form for Kirchoff's Second Law is:

$$\boxed{\sum_{i=1}^{n}(P_i - P_{fi}) - NVP_i = 0}$$

3.2. Method of solving ventilation network.

There are basically two methods of approach to the analysis of the network. The analytical methods involve formulating the governing laws into sets of equations that can be solved analytically to give exact solutions. The numerical methods that have come to the fore with the availability of electronic digital computers solve the equations through iterative procedures of successive approximation until a solution is found to within a specified accuracy.

3.3. Hardy cross method.

In the Hardy- Cross method of analysis, the airflow and pressure drop can be stated as;

$$Q = Qa + \Delta Q$$

$$P = Pa + \Delta P$$

Where:

Qa – initial estimation of the airflow, m^3/s

ΔQ – error in the initial estimation, m^3/s

Pa – pressure drop corresponding to Qa, Pa

ΔP - error in pressure drop corresponding to _Q, Pa

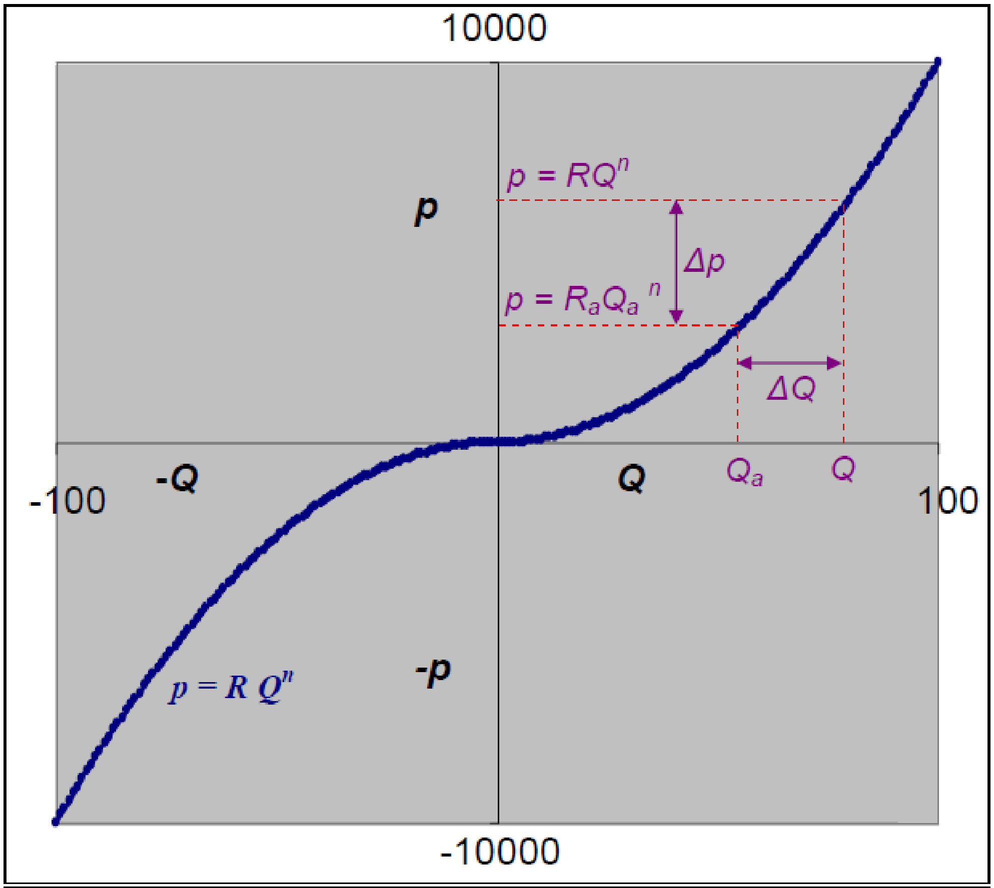

Figure 2. Pressure vs airflow variation at small increments (McPherson, 1993)

The above figure shows a pressure relationship applied to the Hardy- Cross method of analysis of ventilation network.

After differentiate the equation

$$P = R \bullet Q^n$$

The following equation can be derived

$$dP / dQ = n \bullet R \bullet Qn\text{-}1$$

$$\Delta P / \Delta Q = n \bullet R \bullet Qa^{n-1}$$

We know that , $\Delta P = P - P_{a,}$

so substituting the above equation we get :

$$\Delta P = R \cdot Q^n - R \cdot Q_a^n$$

$$\Delta Q = (R \cdot Q^n - R \cdot Q_a^{N-1}) / (n \cdot R \cdot Q_a^{n-1})$$

The above equation is only applicable for a single airway.

Error in the frictional pressure:

$$\Delta P=[\sum^{b}_{t=1} (R_t \cdot Q_t^{nt} - R_t \cdot Q_{tn}^{nt})]/b$$

The general form of ΔQm can be written as,

$$\Delta Qm= [\sum_t{}^{b}{}_{=1} (R_i \cdot Q_t^{ni} - R_i \cdot Q_{ia}^{ni})]/[\sum^{b}_{i=1} n \cdot R_i \cdot Q_{ia}^{ni-1}]$$

The numerator of the above formula gives;

$P_i= R_t \cdot Q^n{}_i$ and represent the frictional pressure drop on airway i.

According to kirchhoff's Second we know that,

$\sum^{b}_{i=1} P_i =0$

By substituting above relation in the equation no. we get,

$$\Delta Q_m = - (\sum^{b}_{i=1} R_i \cdot Q_i^{ni}) / [\sum^{b}_{i=1} n \cdot R_i \cdot Q_{ia}^{ni-1}]$$

The sign of these sum is important because ventilation network has many airways and therefore the recommended rule for sign convention is that the clockwise direction on each mesh should be positive.

Final relationship for

$\Delta Q_m = -[\sum^{b}_{i=1} (R_i \cdot Q_i^{ni} - P_{fi}) - (NVP)_m] / [\sum^{b}_{i=1}(n \cdot R_i \cdot Q_{ia}^{ni-1} - S_{fi})]$

Where,

P_{fi} = fan pressure,Pa

S_{fi}=slope of the fan characteristic,Pa

The mesh correction factor descreases simultaneously with process continuing.

3.4. Monte Carlo method

Monte Carlo means using random numbers in scientific computing. More precisely, it means using random numbers as a tool to compute something that is not random. 'Monte Carlo simulation' is more specifically used to describe a method for propagating (translating) uncertainties in model inputs into uncertainties in model outputs (results). Hence, it is a type of simulation that explicitly and quantitatively represents uncertainties. Monte Carlo simulation relies on the process of explicitly representing uncertainties by specifying inputs as probability distributions. If the inputs describing a system are uncertain, the prediction of future performance is necessarily uncertain. That is, the result of any analysis based on inputs represented by probability distributions is itself a probability distribution.

In order to compute the probability distribution of predicted performance, it is necessary to propagate (translate) the input uncertainties into uncertainties in the results. A variety of methods exist for propagating uncertainty. Monte Carlo simulation is perhaps the most common technique for propagating the uncertainty in the various aspects of a system to the predicted performance.

In Monte Carlo simulation, the entire system is simulated a large number of times. Each simulation is equally likely, referred to as a realization of the system. For each realization, all of the uncertain parameters are sampled (i.e., a single random value is selected from the specified distribution describing each parameter). The system is then simulated through time (given the particular set of input parameters) such that the performance of the system can be computed. This result is a large number of separate and independent results, each representing a possible “future” for the system (i.e., one possible path the system may follow through time). The results of the independent system realizations are assembled into probability distributions of possible outcomes. As a result, the outputs are not single values, but probability distributions.

The accuracy of a Monte Carlo simulation is a function of the number of realizations. That is, the confidence bounds on the results can be readily computed based on the number of realizations. This Monte Carlo simulation Method consists of following steps:

1. Choosing a random value for each input variable according to assigned probability density function.

2. Calculating air quantity at different airways by using a Hardy-Cross method based on selected values in step 1.

3. Repeating steps 1 and 2 for many times as necessary.

4. Determining distribution function of air quantity at different airways.

Following steps were followed in the thesis:

Step 1: The ventilation data from the coal mine was obtained by carrying ventilation survey in different measuring station. The data was tabulated serially to analyse the uncertainity of the fan.

Step 2: Model was plotted and simulated based on the provided data.

Step 3: Based on the individual airways resistance of the actual simulated ventilation network, 200 random normal resistances was generated.

Step 4: Taking the actual resistance as the mean, variance is calculated and 200 more random normal resistances was generated using the man and variance for each airways.

Step 5: Validation of the network model is done by using VENTSIM.

Step 6: Then quantity of airflow in three working faces were obtained.

Step 7: Histrogram were plotted for each of the working face and compared with the histrogarm of the fan quantity.

CHAPTER 4
VENTILATION MODELING

4. VENTILATION MODELING

The simulation of the coal mine ventilation network was performed using the computer ventilation software VENTSIM. The evaluation of airflow in the airways is based on the Hardy Cross method, an iteration estimation method used to adjust the air quantity flow through the airways until the estimation errors lie within acceptable limits.

The ventilation model is designed to reflect the existing mine structure as well as the future planned extension. Each airways carries parameters such as length, height , width, friction…etc. These parameters used to calculate resistance, quantity, pressure.

A very important step in designing a ventilation network is to determine the minimum airfow for different working faces of the mine. The quantity and quality of airflow must meet the airflows required by the Mining Acts and Regulations.

Based on the type of system required, the ventilation model can fix the airflow on a airway.

Ventilation models use a fan database inbuild within the softwate VENTSIM. Each fan curve input in the database is build based on the manufacturer fan curve.

Chapter 5

CASE STUDY:
RESULTS AND DISCUSSIONS

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RESULTS AND DISCUSSIONS

The study was carried out based on ventilation database available from a coal mine under Mahanadi Coalfield Ltd (MCL), Sambalpur. The quantity is measured at different air measuring station and the data was obtained. The study area consists of 71 airways. Details of the existing ventilation system are shown in the Table 1.

Table: 1 details of the ventilation system

DESCRIPTION	**M.M.V**	**Stand-by Fan**
Make	Mechanical machinery pvt. Ltd Kolkata	VOLTAS
Model	A.F.-100	P.V.-200
FAN r.p.m	630	1032
Fan diameter	300cm	200cm
Number of blades	10	08
Blade angle	27.1	25
Present opt. pressure	52 mm of w.g	45 mm of w.g
Operating quantity	7700 cub m/min	5000 cub m/min
Drive motor voltage	3.3 K.V	550 volts
Power	250 k.w(335 hp)	112 kw(150 hp)
Ampere	32	125
Number of V-belts	10	10
Pulley diameter of the fan	80 cms	47.5 cm
Pulley diameter of the drive	35 cms	32 cms
Fan drift (1) avg cross-sectional area (2) length	 15.75 sq m 12 mts	 9.72 sq m 7 mts

The lengths, areas, are perimeters are calculated at different places in airways. For each airway, at least 3 observations were made for lengths, areas, are perimeters. The resistance values are then calculated. The mean and variance of each airways resistance are presented in Table 2. The simulation of the mines ventilation data and model designing is done by using VENTSIM 3.9.3a software.

Table:2. Mean and variance of resistance of 71 airways

Airways number	Mean	Variance
64	0.00294	0.02266
1	0.00296	0.04931
2	0.00219	0.00107
3	0.00073	0.01391
4	0.00109	0.01211
5	0.00144	0.01211
6	0.00613	0.00425
7	0.00065	0.00723
8	0.0158	0.00763
75	0.00032	0.01189
9	0.00973	0.00418
10	0.0004	0.01795
13	0.03825	0.01758
78	0.02634	0.03055
11	0.00058	0.01881
12	0.02471	0.01861
15	0.00081	0.01894
14	0.02529	0.02271
16	0.02524	0.03037
24	0.00319	0.03003
17	0.00088	0.00378
77	0.06499	0.01968
72	0.04556	0.00025
18	0.00067	0.00601
19	0.00161	0.00209
20	0.00615	0.00234
21	0.00123	0.00197
70	0.06623	0.02788
22	0.00076	0.00212
23	0.00516	0.00213
32	0.00193	0.00169
73	0.05212	0.03414
26	0.03871	0.01868
27	0.03988	0.02148
28	0.00029	0.02187
29	0.03808	0.01683
71	0.05192	0.02111
30	0.00048	0.02782
31	0.00038	0.02753

33	0.00075	0.01801
69	0.05106	0.03448
35	0.00179	0.00188
36	0.00227	0.00045
37	0.00121	0.00034
38	0.00204	0.00022
39	0.00143	0.00013
40	0.00547	0.02084
41	0.07269	0.04092
42	0.00469	0.00182
43	0.00296	0.00087
44	0.03242	0.01962
45	0.0011	0.0023
46	0.00121	0.00136
47	0.00094	0.00204
48	0.00031	0.01575
49	0.00038	0.01052
50	0.00212	0.00028
51	0.02193	0.02131
52	0.00144	0.01944
67	0.03698	0.01857
54	0.00367	0.00138
55	0.00231	0.02112
68	0.04612	0.01995
57	0.00071	0.03451
58	0.00266	0.01853
59	0.00033	0.02043
60	0.0004	0.02231
61	0.00062	0.02266
62	0.00136	0.0012
65	0.00048	0.02256
66	0.00197	0.00075

Monte Carlo Simulation was performed to calculate the expected value of quantity flows through different airways, and the risk of not achieving specific quantity in different airways. According to Monte Carlo simulation method, a random value has been selected for each airway resistance based on the assigned probability density function. Theoretically, the more Monte Carlo trials the more accurate the solution will be, but the number of required Monte Carlo trials is dependent on the level of confidence in the solution and the amount of variables being considered. Since, the number of resistance values calculated in each airways are limited, fitting the theoretical distribution functions with these parameters are difficult. In this paper, the distributions are considered Gaussian distribution.

In this Monte Carlo simulation, the ventilation network simulation was performed by Hardy-Cross method. A total number of 200 trials were made for ventilation network simulation. Figure 3 represents the quantity at different airways for a single run. The summary statics of the ventilation network is presented in Table 3. The total mine resistance is found to be 0.01131 Ns^2 / m^8 and the total airflow throughout the network is 7819 m^3/s. Since the variability of the airways resistances are normally distributed, the probability density functions of the safety factors are also normally distributed as expected.

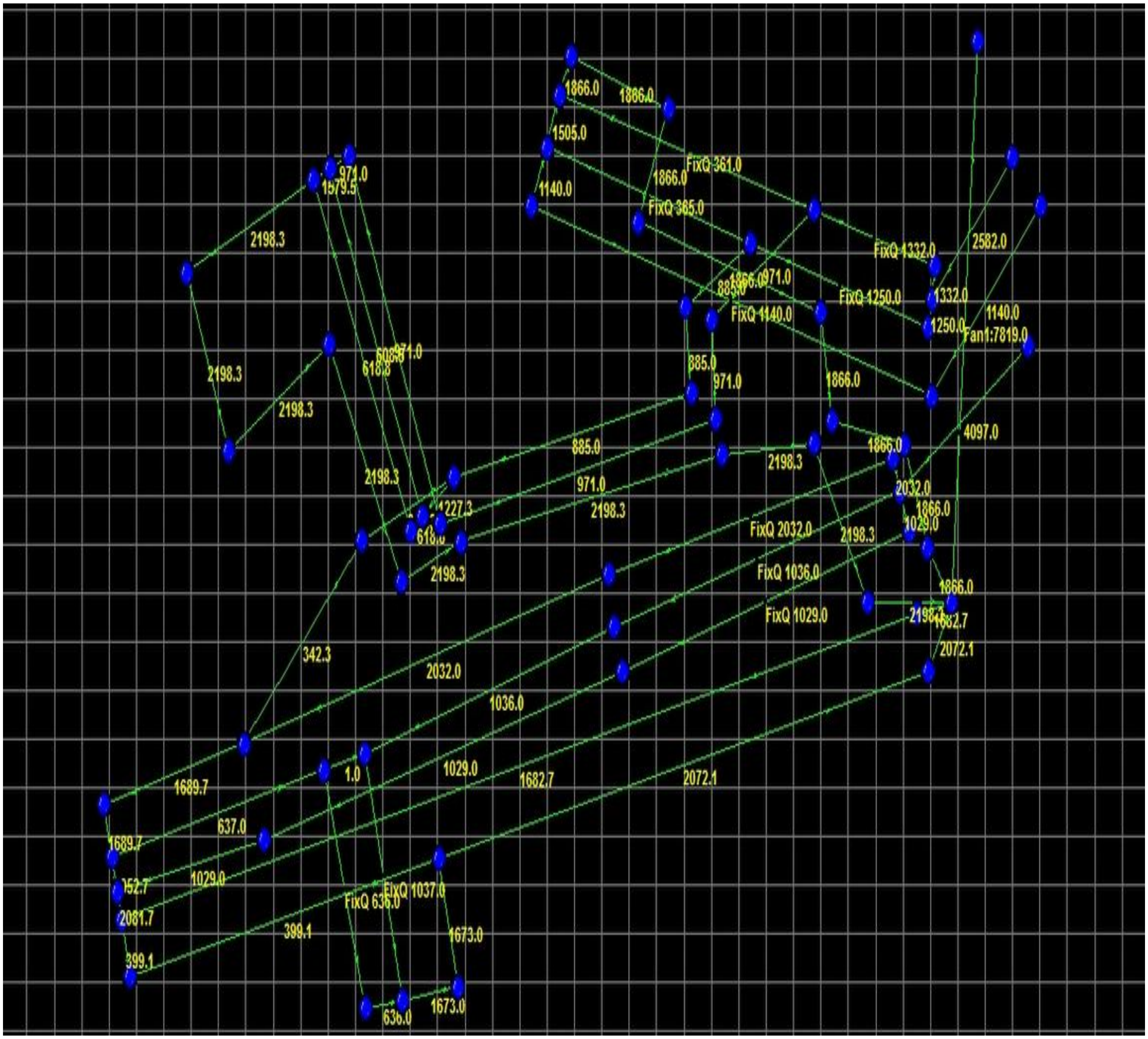

Figure.3 simulated model design of a ventilation network of a coal mine

Table.3. Network summary of the simulated network model.

Total airflow	7819.0 m^3/s
Mine resistance	0.01131 Ns2/m8
Total air power	5407792.0 kW
Network input power	6842841.0 kw
Network efficiency	79%
Number of airways	71
Number of fans	1
Length of airways	18921 m

To perform the uncertainty analysis of quantity reaching at working faces (airways 3, 4, and 50) the histogram and cumulative distribution function (CDF) were generated from 200 Monte Carlo simulations run. Figure 4 and 5 represent the histogram and CDF of quantity in airway 50. From histogram, it is observed that the quantity of air is following the normal distribution with mean value approximately 33 m^3/s. The demand of that airway as per regulation is 35 m^3/s. The CDF figure represents that that with the existing ventilation system, only 40% of time the desired amount of air is reaching to the face.

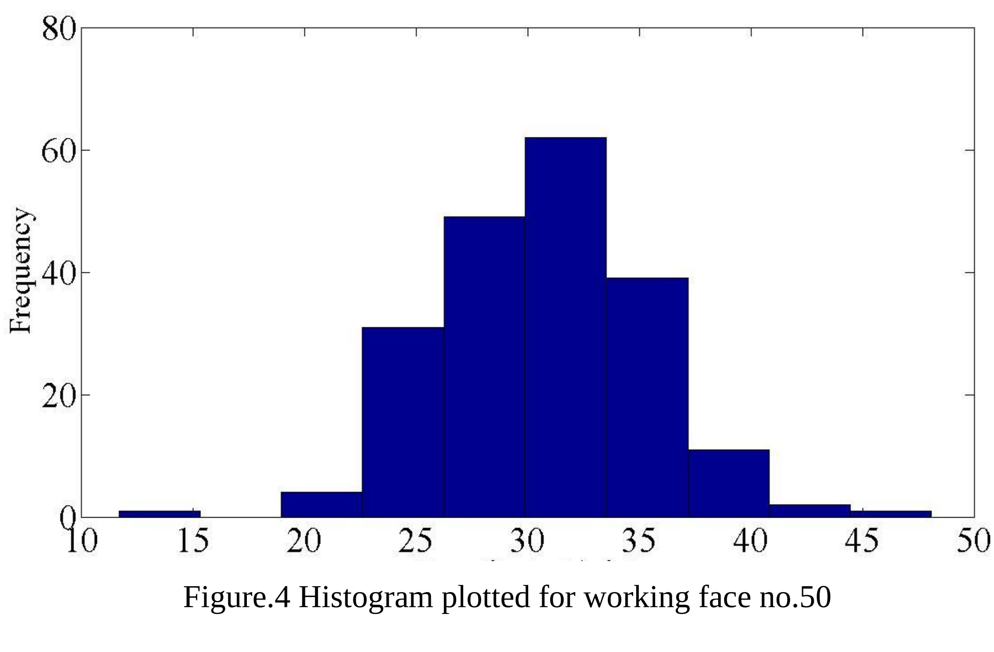

Figure.4 Histogram plotted for working face no.50

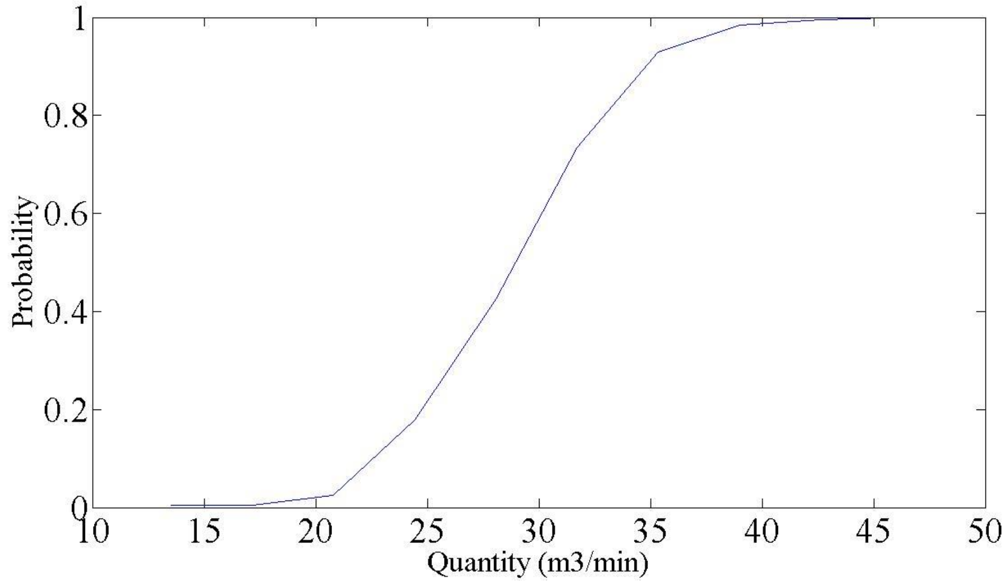

Figure.5 Probability distribution curve for working face no.50

Figure 6 and 7 represent the histogram and CDF of quantity at face in airway 4. The mean quanity reaching that face in 22.3 m^3/s. As per regulation, the amount of air required at that face is 20 m^3/s. Therefore, it is clearly observed from the CDF that the risk of not meeting required quantity 42%.

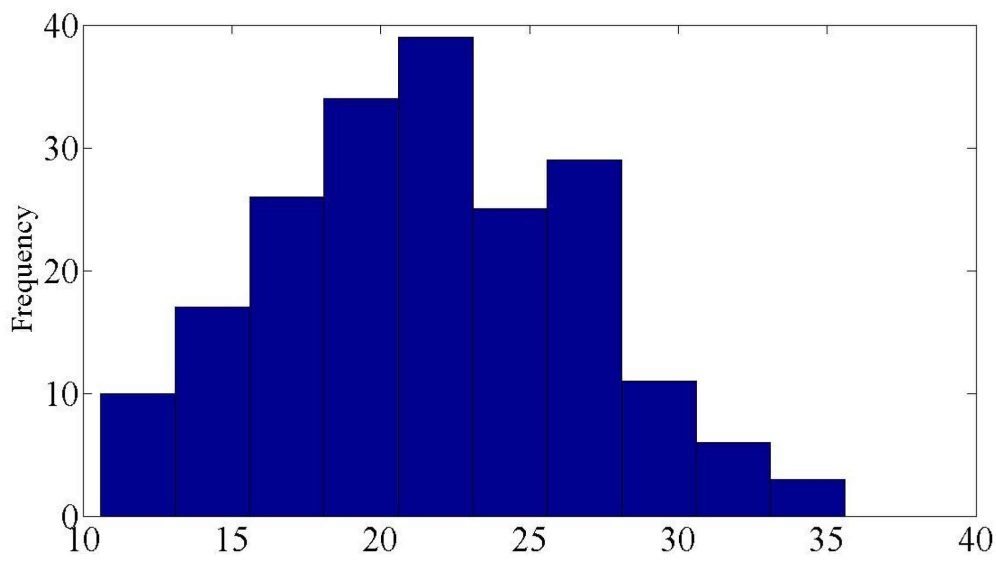

Figure.6 Histrogram plotted for working face no.4

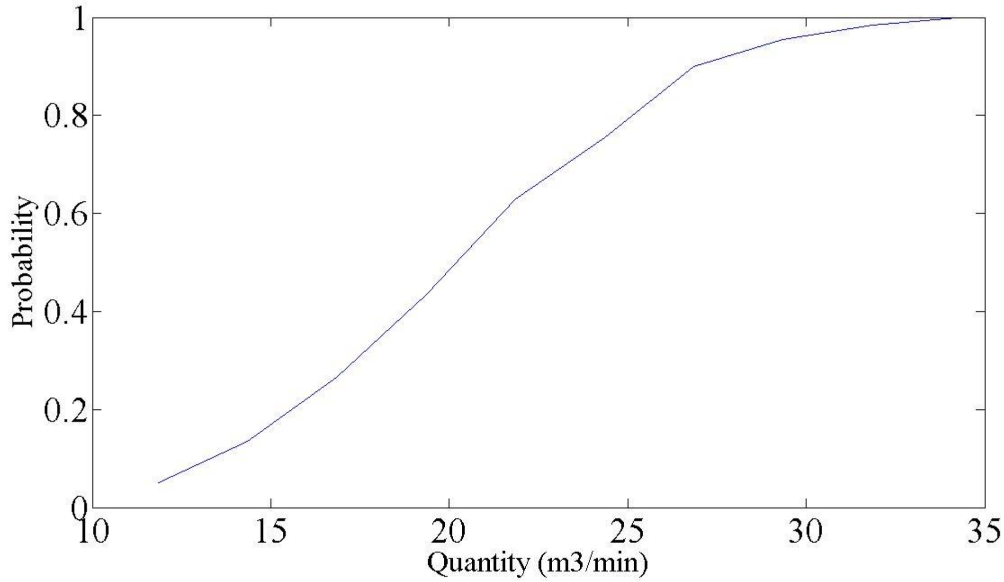

Figure.7 Probability distribution curve for working face no.4

Figure 8 and 9 represent histogram and CDF of quantity of air in airway number 3. The expected air quantity is 9.1 m^3/s and the probability of not reaching the desire quantity of air (10 m^3/s) is 58%.

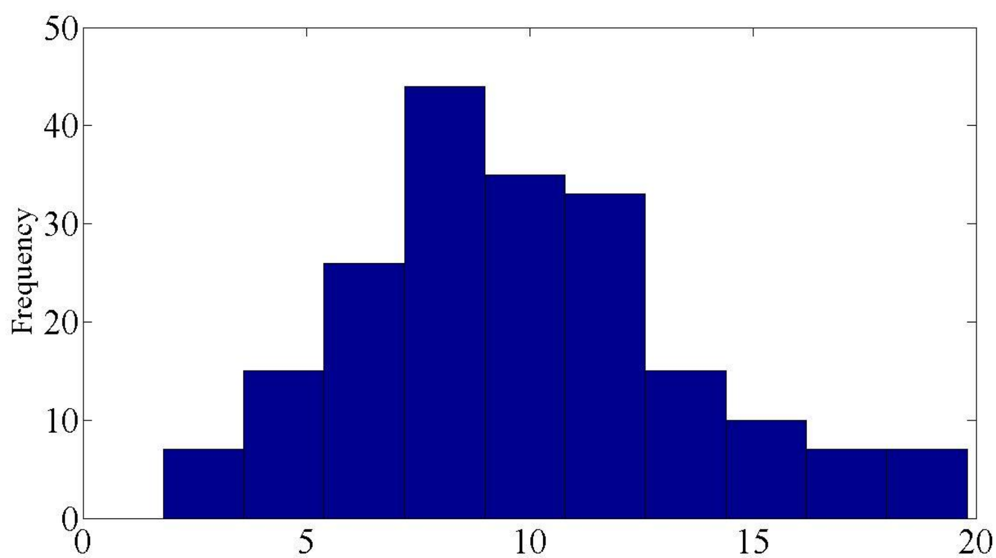

Figure.8 Histrogram plotted for working face no.3

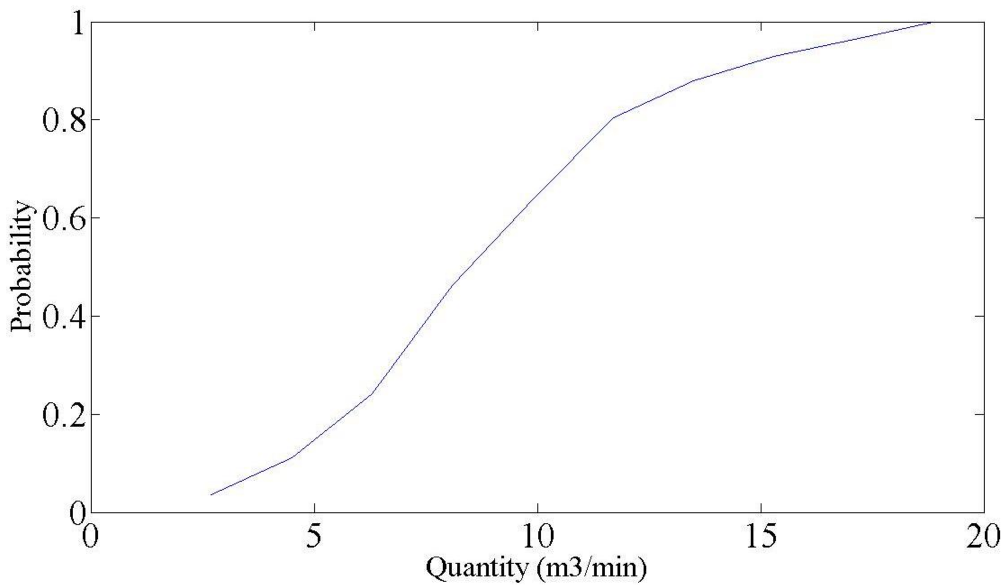

Figure.9 Probability curve of the working face number 3.

Chapter 6

CONCLUSION

Conclusion

The uncertainty analysis of mine fan is studied by simulation network systems. From the above study, the following conclusions can be drawn:

- The maximum and minimum variance simulated is 0.07269 and 0.00029 respectively.
- The maximum and minimum quantity of air flowing to the working face number 50 is 40.1 m^3/s and 11.7 m^3/s
- Only 40% of time the desired amount of air is reaching to the face 50; therefore risk associated is 60%.
- The maximum and minimum quantity of air flowing to the working face number 4 is 35.6 m^3/s and 10.6 m^3/s
- The risk of not meeting required quantity at face number is 42%
- The maximum and minimum quantity of air flowing to the working face number 3 is 19.8 m^3/s and 1.8 m^3/s .
- The expected air quantity at face number 3 is 9.1 m^3/s and the probability of not reaching the desire quantity of air (10 m^3/s) is 58%.

Chapter 7

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